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HUMAN PHYSICAL ACTIVITY RECOGNITION ALGORITHM BASED ON SMARTPHONE DATA CONVOLUTIONAL NEURAL NETWOrK AND LONG SHORT TIME MEMORY

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Annotation. A deep learning framework for activity recognition based on smartphone acceleration sensor data, convolutional neural network (CNN) and long short-term memory (LSTM) is proposed in the paper. The proposed framework aims to improve the accuracy of human activity recognition (HAR) by combining the strengths of CNN and LSTM. The CNN is used to extract features from the acceleration data and the LSTM is used to model the temporal dependencies of the features. The proposed framework is evaluated on the publicly available dataset, it includes 6 different actions: walking, walking upstairs, walking downstairs, sitting, standing, laying. The physical activity recognition accuracy has reached 94 %.

Keywords. HAR, CNN, LSTM, Acceleration sensor.

With the rapid popularity of smartphones and the rapid development of micro sensors, various MEMS sensor devices are embedded in people’s smartphone. The main advantages of MEMS sensors are small size, light weight, low power consumption, high reliability, high sensitivity, easy integration, etc. And the research on human behavior recognition based on sensor-based intelligent devices has become an emerging research topic in recent years, traditional machine learning algorithms extract feature vectors from data to distinguish between classes of activities, and researchers have done a lot of research work in this area. FGD Silva [1] used two methods, FDR and PCA, to extract 19 features from the data and used SVM method to classify the activities, VNT Sang [2] applied KNN, ANN and SVM algorithms for classification and recognition of human behavior, R Singh [3] et al. proposed an algorithm for human state recognition activity using decision tree C4,5 by data mining algorithm. Since traditional machine learning algorithms require manual extraction of features in the data, and it is difficult for non-professionals to extract effective feature sets, manual extraction is also subject to human error and time-consuming, all of these methods which will reduce the accuracy of classification and recognition, but neural networks greatly compensate for the lack of manual feature extraction in traditional machine learning by building a multi-level automatic feature extraction architecture.

Data acquisition for human behavior recognition is basically divided into two categories, video image-based data acquisition and wearable sensor-based data acquisition. In this paper, we focus on human activity recognition based on wearable sensing data. This paper uses the built-in acceleration sensor of a smartphone for data collection.

The network model consists of three convolutional layer and LSTM network layers, fully connected layer, and one Softmax layer, and predicts the corresponding human actions from the data set. The proposed algorithm’s accuracy achieved 94 % and the loss is about 0,02 at the test set.

The algorithm which we proposed consists of six different layers: three 1D convolutional layers, LSTM network layer, fully connected layer, and Softmax layer. The structure diagram of the algorithm is shown in Figure 1.

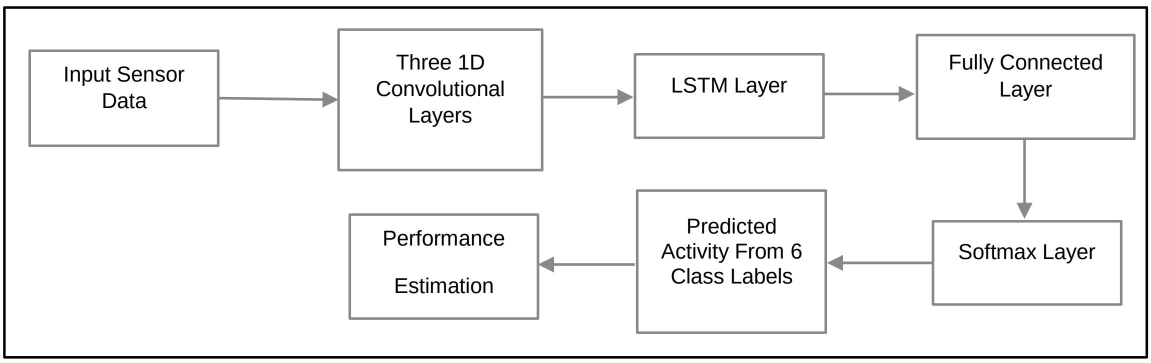

Figure 1 – The block scheme of physical activity recognition algorithm based on CNN-LSTM neural network

We tested the recognition accuracy of the algorithm using data from the publicly available dataset UCI-HAR. In this dataset, 70 % of the volunteers was selected for generating the training data and the remaining 30 % is used to test the data. We set the training set to 100 and train on the training set for 50 epochs. The loss value and the accuracy values are shown in Figure 2.

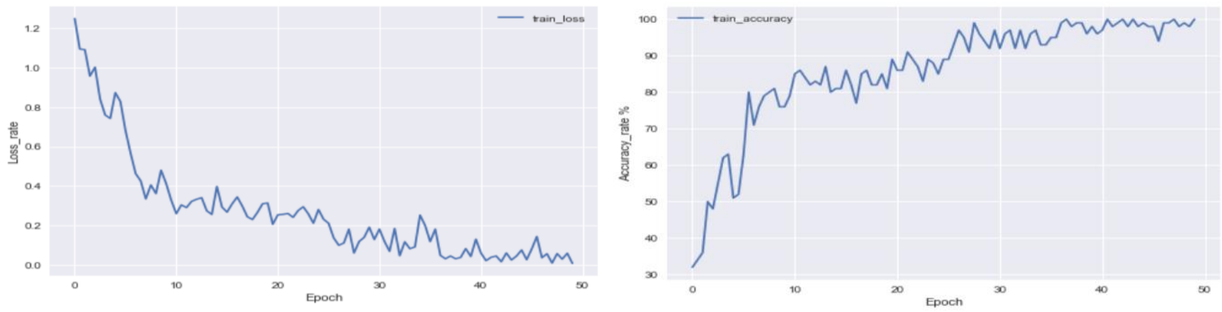

Figure 2 – Loss and accuracy rate of the CNN-LSTM model

In the second experiment, to predict human activities, we used only a pure LSTM algorithm for comparison with our algorithm. This choice was made because human activities are sequences of actions, and LSTMs are known for their effectiveness with time series sensor data. By capturing temporal dependencies from this data, the LSTM model was able to achieve an accuracy of 92.98%. The experimental results are illustrated in Figure 3, which displays the training and validation loss.

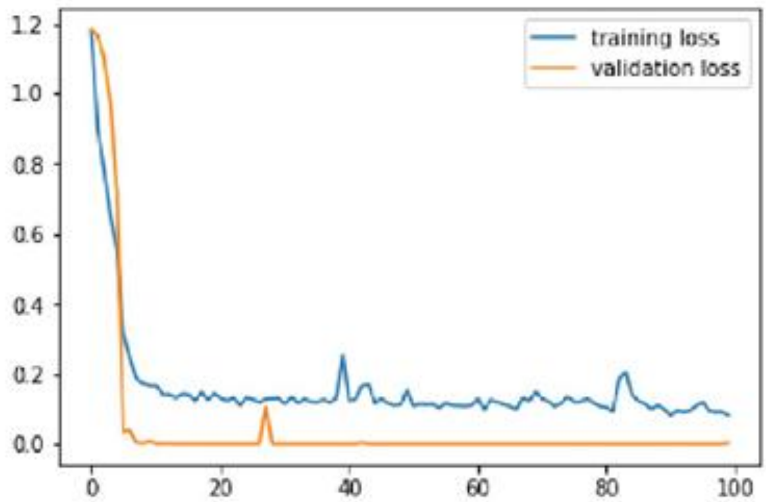

Figure 3 – Training and validation loss of LSTM

We conducted experiments using different optimizer such as stochastic gradient descent (SGD), Adagrad, RMSprop and Adam. We decided to use Adam as an optimizer based on our preliminary results. Experimental results showed the accuracy of 94 % which outperformed different forms of LSTM models used in this dataset. The adding of additional layers did not show any significant accuracy improvement but only increased the computational cost. Therefore, we decided to keep our CNN-LSTM algorithm simple by keeping three 1D convolutional layers and one LSTM network. The experimental results showed the advantages of using hybrid model over pure and other forms of LSTM models. We also compared our results with state-of-the art LSTM models proposed on same dataset. The comparison of performance of other LSTM models on UCI HAR dataset is given in the Table 1.

Table 1 – Performance comparison on UCI HAR dataset

Algorithm	Accuracy
LSTM-CNN	94,00 %
LSTM	92,98 %
Bidirectional LSTM [4]	92,67 %
Res-LSTM [5]	91,60 %
Baseline LSTM [5]	90,80 %

The performance comparison table shows the effectiveness of our CNN-LSTM model compared to state-of-the-art methods used for LSTM, Bidirectional LSTM, Res-LSTM and Baseline LSTM model on same UCI HAR dataset. The CNN-LSTM model yield better recognition score than applied LSTM model and outperformed other forms of LSTM used for activity recognition in the same dataset.

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